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ABSTRACT

This paper describes the process by which a television test was developed to measure elementary student competencies in science processes. The test was developed as an evaluative tool, related to the Pennsylvania Department of Education's Science for the Seventies project of televised science modules designed to supplement classroom science instruction. The Test of Science Processes was used as a base, but was modified to use with elementary school children and the television medium. (STS)

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MEASUREMENT OF SCIENCE PROCESSES IN INTERMEDIATE GRADES THROUGH INSTRUCTIONAL TELEVISION

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MEASUREMENT OF SCIENCE PROCESSES IN INTERMEDIATE GRADES

THROUGH INSTRUCTIONAL TELEVISION

BACKGROUND

During the past several years, scientists and science educators have expressed a need to emphasize the processes of science as unique and coequal with the product or content of science. As a result, many science curricula have incorporated science processes as a teaching priority.

In 1968, the Pennsylvania Department of Education (PDE) embarked on a statewide thrust to assist elementary teachers in a transition into some of the newer methods of teaching science. This effort was called Science for the Seventies (PDE, 1971). In 1972, the Pennsylvania State University and PDE devised a system for using instructional television as a major resource in the dissemination and implementation of Science for the Seventies (SFTS) for elementary school classrooms throughout Pennsylvania. (Shrigley, Alfke, Szabo, and Welliver, 1975)

It encompasses a teacher's guide which deals with the pedagogy of contemporary elementary science education, a growing set of primary and intermediate grade science lessons, ten 15-minute televised programs for use with primary grade students, ten 20-minute televised programs for use with intermediate level students, five in-service televised programs to help teachers use SFTS-ITV Handbook for Teachers which provides an orientation and instructions in the use of the resource (PDE, 1975). The function of SFTS in the science curriculum is summarized as having the following role:

> SFTS, including both the TV components and the printed materials, is not a K-6 science curriculum; rather, it is a resource for teachers. The philosophy of SFTS is compatible with such inquiry programs as SCIS, ESS, and S-APA. Therefore, SFTS could serve as either a bridge or a supplement to any of the three programs mentioned.
>
> Secondly, SFTS could be the model around which a school district could build, over the years, a K-6 inquiry-type science curriculum. This would mean adding many lesson components to the 25 published by PDE.
>
> Thirdly, SFTS could be the inquiry component to a conceptually oriented science curriculum. Teachers could pick and choose those lessons that reinforce an already established curriculum.

> Fourthly, the SFTS tapes and the accompanying lessons, plus SFTS lessons published but not placed on tape, comprise enough materialszto provide a four-month springboard to science for new primary grade teachers in a school district. Or a school district having no ongoing science curriculum might introduce all of its primary teachers (and perhaps intermediate teachers) and pupils to investigate science teaching through the four-month SFTS resource. (Shrigley, et al., 1975, p. 501)

One of the stated objectives of this statewide ITV resource emphasizes science processes:

> Following the broadcasting of SFTS oriented televised lessons, children in participating classrooms will exhibit a measurably significant increase in their facility in the use of science processes. (SFTS Phase I Project Report, 1974, p. 21)

Relative to the above terminal performance objective, a tentative projected performance measure was drafted:

> A televised test will reveal increased student competency in the use of science processes and attainment of aims and objectives of SFTS. (SFTS Phase I Project Report, 1974, p. 24)

Once the decision to use a test of science processes to gather data about intermediate grade school children in Pennsylvania was made by members of the Science for the Seventies Committee, several tests were investigated for possible use. No test reviewed possessed the combined requirements of being valid for use by intermediate level students and for use via the television medium. However, of the available tests purporting to measure science processes, the Test of Science Processes (Tannenbaum, 1968) was judged to be adaptable for intermediate grade use because it was an instrument at least possessing content validity. Also the processes categorized as subtests by the author encompassed most of the processes listed by science educators. Most applicable to the SFTS objectives was its visual presentation mode which had implication for the television format. A television format has the advantage of providing repetition, clarification, and motion cues to the questioning procedure. There were two reasons why the Test of Science Processes in its original form was not appropriate for use as the assessment instrument for the SFTS: (1) the test was designed for junior high school level, and (2) it was designed for 2x2 35mm slide presentation.

Statement of the Problem

Because television is a major component of the SFTS resource, it was logical for a test to be produced in the same medium. A television test would compliment the total SFTS television package, would provide a free testing resource to teachers and administrators, and would provide uniformity in test administration. Television provides the least expensive delivery system for the presentation of the visuals required in the testing situation.

There were two aspects to the problem investigated in this study. First, could the Test of Science Processes be modified for use by intermediate level students; and second, could the TSP be adapted for use through the medium of television? The adaptation of an existing instrument involved a replication of the steps used to create the initial instrument as well as the addition of several new steps unique to the production of the second instrument. These steps were to derive content validity, to produce the print and non-print components, to establish the reliability through item analysis, to empirically validate and to establish norms.

Importance of the Project

The Television Test of Science Processes (TTSP), relative to the Science for the Seventies ITV resource, has several potential benefits: (1) provide pretest entry data in an empirical study to measure the effectiveness of SFTS exposure, (2) survey general student normative performance on science processes on a statewide scale, and (3) offer an additional evaluative instrument to assess mastery of science processes.

In a more general sense, production and validation of the TTSP provides a useful addition to the small number of tests of science processes available to educators. The instrument is unique in its televised modality. It should be a valuable resource for elementary science teachers and administrators, researchers in elementary science education, instructional developers working with television projects in elementary science, and should provide a valuable source of data for continuing research in elementary science, process testing, and television testing.

Review of the Literature

A review of the literature found considerable support for the need to teach those skills and abilities employed by scientists and identified by psychologists and educators as science processes. However, no general agreement in the list of those skills and abilities was found. This imprecision was canoted in the Dictionary of Education which lists this open-ended definition:

> Process approach, an approach to science instruction in which children learn generalizable process skills that are behaviorally specific but which carry the promise of broad transferability across many subject matters; it adopts the idea that novel thought can be encouraged in relation to each of the processes of science, such as observation, inferrence, communication, measurement, etc. (Good, 1973, p. 439)

This ambiguity of terminology portends difficulty to the test developer who attempts to measure science processes. If no uniformity exists, the test developer must define those characteristics to be assessed by his unique instrument. This could result in a proliferation of instruments which measure unique factors wholly different from other instruments but are collectively labelled science process tests. Table I is a summary of those processes applicable to selected educators, educational psychologists, and science curricula.

Several tests have been developed to assess the acquisition of those skills and abilities collectively described as science process. Some of the tests are the S-APA (Science -- A Process Approach), Science Process Instrument (SPI), American Association for the Advancement of Science, 1970; the Processes of Science Test, Biological Science Curriculum Study, 1962; The Science Process Test (TSPT), Ludeman, 1974; the Science Observation and Comparison Test (SOCT), Hungerford and Miles, 1969; the Science Test for Evaluation of Process Skills (STEPS), Morgan, 1971; the Test of Science Processes (TSP), Tannenbaum, 1968; and the science test of the Comprehensive Tests of Basic Skills (CTBS), McGraw-Hill, 1973.

Each of these tests is designed for varying grade levels, ranging from fourth to twelfth grade. None of the tests is for television presentation.

The literature revealed a scarcity of testing via television. Of the studies reporting on television testing, most have concluded that television presentation of tests has several advantages over traditional modes of testing. The literature suggested that testing could be effectively conducted through the medium of television.

TABLE I

PROCESSES APPLICABLE TO SELECTED EDUCATORS, EDUCATIONAL PSYCHOLOGISTS, AND SCIENCE CURRICULA

Processes	Tannenbaum	AAAS	Shamos (COPES)	Jevons	Gagne	Curtis	Atkin	Conant	SCIS	ESS	Kessen	Keeslar
observing	X	X	X	X	X	X			X		X	
comparing	X		X						X		X	
classifying	X	X	X	X	X				X		X	
quantifying	X				X							
measuring	X	X	X	X					X		X	
experimenting	X		X	X							X	X
inferring	X	X		X	X							X
predicting	X	X	X	X					X			
communicating		X				X						
recognizing and using time space relationships	X											
interpreting		X						X				
evaluating		X									X	X
discriminating		X										X
describing		X		X								
identifying and differentiating			X									X

TABLE I (cont'd)

Processes	Tannenbaum	AAAS	Shamos (COPES)	Jevons	Gagne	Curtis	Atkin	Conant	SCIS	ESS	Kessen	Keeslar
inducing and deducing			X									
hypothesizing			X								X	X
orienting				X								
making conceptual models				X								
reasoning					X							
drawing conclusions											X	X
recognizing and using numbers and number relationships		X										

PROCEDURE

The procedure for modifying the Test of Science Processes (TSP), and adapting it for television required the following steps: (1) present the question content of the TSP to a panel of judges on elementary science curriculum and instruction to ascertain the content validity of the test as applicable to intermediate level students, (2) rewrite those questions recognized appropriate by the experts to conform to the readability adequate for upper elementary students, (3) produce a pilot test composed of the adapted questions on quadraplex video tape and produce the associated print materials, (4) provide a pilot exposure and techniques to ascertain appropriate test item exposure time, (5) edit the video production to conform to the time data, (6) provide a pilot run of the televised test to a large number of students to amass data for item analysis, (7) establish statistical parameters by which the item analysis would provide a refinement of those questions which would comprise the final form of the test and edit the video production accordingly, (8) provide for broad exposure of the test to ascertain norms for target populations; and (9) provide an experimental study to amass concurrent and predictive validity data. The following is a summary of those activities that were necessary to complete the study.

An item pool was generated from the ninety-six items of the Test of Science Processes which were a representative sample of the eight science processes identified and defined in Appendix B and applicable for the intermediate level with minor revision. These questions were chosen on the basis of their requiring the skills and abilities recognized as process skills and on the basis of their applicability to intermediate level students. The question selection was performed by a panel of elementary science educators of The Pennsylvania State University whose credentials reflect a high degree of experience in research and teaching and are recognized both nationally and internationally as possessing a high degree of expertise by the academic community.

After the item pool was identified, an implementation procedure was pursued to produce the print and non-print components to form a prototype Television Test of Science Processes. The print component consisted of a television test booklet and teacher's manual. It involved a careful review of the verbal component, the visual digital information, modification of the test items' vocabulary and syntax to conform to a readability level applicable to the intermediate level. The modified verbal message was subjected to two readability measures to ascertain its appropriateness for the target population. This was performed and the resultant study found both vocabulary and syntax to be appropriate. Question answers and distractors were scrambled in a random manner using a table of random numbers for answer replacement. Upon completion of the total print message, it was organized and printed in the format of the Test of Science Processes.

The non-print component was reviewed and organized in a television script into the audio and visual modes. It was decided that the narration of the questions and the answers were too time consuming and were distracting. The visual information was reviewed for optimal television presentation. For clarity of visuals, implementation of motion where appropriate, cost considerations, and production techniques, it was decided to record all visual information on two-inch video tape of broadcast quality. Using the production studio of WPSX, the entire verbal and visual information was produced. After an introduction and directions for taking the test, the question visuals and question narration preceded by the appropriate number were recorded for each of the sixty-eight questions of the identified item pool. From the end of the narration to the next item, visuals were shown for ninety seconds. This video tape package combined with the print component formed Form A of the Television Test of Science Processes, the prototype or research instrument for further study.

To ascertain the appropriate timing for each of the visuals, Form A of the TTSP was subjected to an item response time study. A population of central Pennsylvania fifth grade students were identified and given Form A of the instrument. Graduate students of The Pennsylvania State University recorded the times for each student to respond to each question inclusive of corrections. Using the rule of the 90th percentile, a cutting time was identified for each question. The video tape was edited to conform to the appropriate times. The edited tape became Form B of the test instrument.

Plan for a pilot exposure of Form B to a large population of intermediate level students to derive item analysis data was facilitated through contacts made with the Pennsylvania Department of Education. The instrument was piloted in a large suburban Philadelphia school system using closed-circuit television. Data was amassed on a large population and, using established guidelines for accepting or rejecting items on the basis of point biserial correlations and difficulty, forty items were identified for inclusion into Form C of the Television Test of Science Processes. Revision of the entire print and non-print component was effected to conform tto the item analysis data. The print material was revised and new booklets printed. A major edit of the video tape was conducted to renumber all appropriate remaining questions, to include appropriate credits, and to conform to the time limits of two 30-minute programs required for public broadcasting.

Public broadcasting over the service area of the Allegheny Educational Broadcast Council of Pennsylvania provided massive exposure and the gathering of a large data fund for a norming study. Test results from 3,480 fifth grade students from nineteen school systems of varying profiles were processed and tabulated into percentiles and T-scores and plotted into a frequency distribution.

A study to determine validity was initiated. In conjunction with a large central Pennsylvania school system, data were gathered from a large population of students on a variety of variables. The students were given the TTSP, TSPT, the Science Test of the CTBS over a span of one year. This and other data were collected within safeguards of confidentiality and recorded on EDP cards. Information on fifteen variables were processed using the Pearson product-moment correlation and factor analysis programs. Within the guidelines established for a statement of criterion-related validity, it was found that the Television Test of Science Processes, Form C was moderately to highly correlated with The Science Process Test and the Science Test of the Comprehensive Test of Basic Skills.

FINDINGS

This was a developmental study in which a normative test to assess performance in the use of certain of those skills and abilities identified as science processes by intermediate level students through the medium of television was created. Information generated in this endeavor included that which was necessary for the modification and adaptation of the Tannenbaum instrument as well as spurious information recommending further inquiry. The steps involved were to develop an item pool consisting of those questions from the Test of Science Processes which were representative of the science processes and were applicable for intermediate level students; to rewrite the selected questions so as to make them more easily read by intermediate level students; to produce a pilot test; to provide a pilot exposure to ascertain test item exposure time; to edit the video tape for appropriate timing; to pilot the test on a large population to amass data for item analysis; to develop the final form of the test by selecting questions appropriate through statistical parameters set by performing an item analysis; to provide a broad exposure of the test to ascertain norms for target populations; and to provide an empirical study to gather concurrent and predictive validity data. The steps have taken into account or considered the standards of the American Psychological Association (1974) for test developers of educational and psychological tests.

The data suggests content validity, appropriate readability, internal reliability coefficients approximating comparable reliability coefficients of tests of science processes, criterion related validity through moderate to high correlation with similar instruments, and a norming distribution with a moderate unimodal skew approximating a normal curve. The correlation between the TTSP and the TSPT was .66. The correlation between the TTSP and the Science Test of the CTBS was .66. Both correlations coefficients are significantly different from zero at the .01 level. Table 2 is a summary of the statistics for the norming sample on the TTSP, Form C. Table 3 is a summary of the statistics for the validity sample on the TTSP, Form C. The TTSP is a test which measures the relative achievement of those cognitive skills and abilities that we term science process. This study presented information about the relative ordering of individuals with respect to their TTSP test performance. A conclusion can be inferred that the successful formulation of the TTSP implies that the Test of Science Processes has been modified for use for intermediate level students and has been adapted for use through the medium of television.

TABLE 2

STATISTICS FOR THE NORMING SAMPLE ON THE TTSP, FORM C

Grade level	5
Number of students	3480
Mean score	15.96
Standard deviation	5.35
Standard error of measurement	2.75
Mean point biserial	0.294
KR-20 reliability	0.736
Mean difficulty	0.399
Test range	.38
Standard error of test mean	0.09
Skewness	0.39
Kurtosis	3.21

TABLE 3

STATISTICS FOR THE VALIDITY SAMPLE ON THE TTSP, FORM C

Grade level	5
Number of students	203
Mean score	18.86
Standard deviation	6.29
Standard error of measurement	3.03
Mean point biserial	0.352
KR-20 reliability	0.816
Mean difficulty	0.497
Test range	29
Standard error of test mean	0.44
Skewness	0.31
Kurtosis	2.38

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